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David C. Fritts

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Research during the past year included both theoretical and observational studies of gravity waves and their effects in the lower and middle atmosphere. Theoretical studies examined the stability conditions of inertio-gravity waves in order to address the most likely form of wave instability and saturation as well as the atmospheric structures leading to ducting and wave energy transports. Ongoing theoretical studies are addressing nonlinear wave interactions and wave forcing via geostrophic adjustment. Observational work has dealt with mesospheric momentum fluxes at high latitudes and with continuing studies of wave and turbulence effects using a variety of data sets. Future work will address increasingly the sources and variability of such motions.

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Annual Technical Report

This report summarizes work performed under AFOSR Contract F49620-87-C-0024 during the second year of support (1/1/88 to 12/31/88), describes our progress in attaining the research goals, and lists the personnel involved and the publications resulting to date.

1. Research Progress

Our research efforts this last year included both experimental and theoretical components. Experimental work involved both continuing efforts to improve the control and data analysis equipment for the ST radar and work with data collected with the Poker Flat MST radar. The former included the design and construction of a new pulse box for the ST radar at the Poker Flat Research Range that will allow more flexibility in the computer control of the radar operating conditions and permit simpler data acquisition. We are now proceeding with testing of the interface of the various components and expect to be collecting radial velocity data in a routine fashion in the near future.

Other experimental work has used data from the Poker Flat MST radar used in a high-resolution mode for mesospheric observations of gravity wave momentum fluxes. This work

revealed mean momentum fluxes as large as 20 m^2/s^2 with hourly values as much as three times this large. These results suggest that the high-latitude summer mesopause is a region in which gravity wave motions provide a very significant forcing of the large-scale flow. This study is currently under review by J. Atmos. Sci.

Our theoretical work during this year of support included the completion of a study of the ducting of gravity waves in a complex environment allowing for the coupling of different regions of the atmosphere via an analog of quantum-mechanical tunneling (under review by J. Geophys. Res.) and studies of the dynamical instability of a low-frequency gravity wave in the absence and presence of a mean shear (one paper in press and a second submitted to J. Atmos. Sci.). Other work of a more preliminary nature includes an investigation of nonlinear wave-wave interactions in a complex environment, the continuation of an analysis of the excitation of inertio-gravity wave motions by geostrophic adjustment, an investigation of the influence of wave and chemical effects on the ion/neutral density ratio in the ionosphere, and a study intended to assess the possibility of solitary wave propagation arising from the complex modal structures observed to occur in our study of ducting processes.

2. Direction of Future Research

Our research during the next year will continue along the lines of our current studies, with hopefully, a greater emphasis on the ST radar data as that becomes routinely available. In particular, we expect to focus on gravity wave sources through measurement of the detailed atmospheric structure in the troposphere and lower stratosphere. This capability will be considerably enhanced if we are able to implement a RASS system for parallel temperature measurements. Initial indications are that our frequency will be very well suited to this purpose.

Theoretical work will continue in parallel with our experimental/observational studies in order to understand as fully as possible the gravity wave source and propagation conditions prevalent in the lower atmosphere.

3. Project Personnel

The project currently has three active graduate students. Li Yuan has participated in most of the studies reported above, Shaojian Sun is working with nonlinear wave-wave interactions, and Zhangai Luo is using Grenn's functions to examine the geostrophic adjustment of inertio-gravity waves. In addition, a post doc has just joined the group and will be involved in both theoretical and data analysis work.

4. Publications

Presented below is a cumulative list of publications that are either in press or submitted citing this AFOSR support.

Fritts, D.C., S.A. Smith, B.B. Balsley, and C.R. Philbrick, 1988: Evidence of gravity wave saturation and local turbulence production in the summer mesosphere and lower thermosphere during the STATE experiment, J. Geophys. Res., 93, 7015-7025.

Fritts, D.C., T. Tsuda, T. Sato, S. Fukao, and S. Kato, 1988: Observational evidence of a saturated gravity wave spectrum in the troposphere and lower stratosphere, J. Atmos. Sci., 45, 1741-1759.

VanZandt, T.E., S.A. Smith, T. Tsuda, D.C. Fritts, T. Sato, S. Fukao, and S. Kato, 1989: Studies of velocity fluctuations in the lower atmosphere using the MU radar: I. Azimuthal anisotropy, J. Atmos. Sci., accepted.

Fritts, D.C., T. Tsuda, T.E. VanZandt, S.A. Smith, T. Sato, S. Fukao, and S. Kato, 1989: Studies of velocity fluctuations in the lower atmosphere using the MU radar: II. Momentum fluxes and energy densities, J. Atmos. Sci., accepted.

Fritts, D.C., and L. Yuan, 1989: A stability analysis of inertio-gravity wave structure in the middle atmosphere, J. Atmos. Sci., in press.

Yuan, L., and D.C. Fritts, 1989: Influence of a mean shear on the dynamical instability of an inertio-gravity wave, submitted to J. Atmos. Sci.

Fritts, D.D., and L. Yuan, 1989: An analysis of gravity wave ducting in the atmosphere: Eckart's resonances in Thermal and Doppler ducting, submitted to J. Geophys. Res.

Fritts, D.C., and L. Yuan, 1989: Measurement of momentum fluxes near the summer mesopause at Poker Flat, Alaska, submitted to J. Atmos. Sci.